county highway department a large sum of money by donating and defraying the cost of the purchase of land for the road, moving buildings back, disposing of the trees and defraying the cost of drainage consisting of an 8-inch tile running parallel with the road, and also defraying the cost of catch basins and the glazed tile which was laid to cross the road at every 200 feet. The estimated cost of the drainage along the highway if the County bore this expense would be $1.50 per front foot, but this was paid by the property owners.

In view of my experience in doing a small amount of this work, and considering its first cost, the maintenance after completion, and the compliments received from the travelling public, I have come to the conclusion that anyone building this type of road according to specifications in detail cannot help getting a good road satisfactory to the taxpayers.

EFFICIENT OPERATION OF A COUNTY ROAD DEPARTMENT

By O. S. Hess, Engineer-Manager, Kent County Road Commission, Grand Rapids, Michigan

A discussion of this subject will, no doubt, prove to be of greater interest if a specific example is used throughout. Accordingly, we will take Kent County, Michigan, as the example and explain more or less in detail the methods of operation in this county.

Kent County lies near the middle of the western side of the Lower Peninsula. It is 24 miles wide and 36 miles long, and has 24 townships. The valuation of the county is approximately $350,000,000, and Grand Rapids is its principal city.

Before going into details of the operation of this county's highway department, we should know something of the administrative setup of the highway organization as well as the governmental structure which controls it. The governing body of the county consists of 52 supervisors—one from each of the 24 townships, 24 from the city of Grand Rapids, and 4 from the city of East Grand Rapids. The board of county road commissioners consists of 3 members who are appointed by the board of supervisors. The road commissioners are appointed for terms of six years each, alternating so that one commissioner must be either reappointed or replaced every two years. The board of county road commissioners is an administrative body only, and does not directly handle the details of the county highway work. This board is required by law to employ a competent engineer to act as the executive head of the county road activities. The road commissioners do not receive high salaries and meet only one day each week

for the purpose of determining policies and business methods which are to be carried out by the engineer-manager through his organization, which is directly responsible to him. In other words, the engineer-manager is the connecting link between the administrative body and the actual execution of the work.

The working organization which is responsible to the engineer-manager is made up of five departments with an executive head for each department. These departments are:

1. Accounts and Records
2. Engineering
3. Maintenance
4. Equipment Repairs
5. Forestry and Parks

It should be mentioned here that by virtue of a state law the board of county road commissioners is also the board of county park commissioners and is the legal custodian of all county parks. This is the reason for the last-named department. Each department head has his own organization, which is directly responsible to him and over which he has complete control.

Soon after the county road system was adopted in 1912, a bond issue of $600,000 was sold and roads were constructed as long as this money lasted. Following this, money was appropriated each year by the board of supervisors and spread as a tax on the county at large. For a number of years this amounted to one-half mill on the assessed valuation of the county. In 1915, an assessment district road law was passed by the legislature, and for a number of years roads were constructed under this act in addition to work provided by the one-half mill tax. This assessment district law provided for the sale of bonds and a division of the cost between the county at large, the township or townships at large, and the assessment district. In a few years, work carried out under this act built up a fair-sized bonded indebtedness. Since 1920, however, a very limited amount of work has been carried out under this law.

During the past ten years our work has been financed largely by a one mill tax plus motor vehicle funds returned to the county by the state. During this period, the bonded indebtedness has been pretty well paid off, so that we now find the county practically free from bonded indebtedness for highways and on a strictly pay-as-you-go basis. The motor vehicle funds coming to the county road commission now amount to nearly a half million dollars per year. This will be nearly our entire income for highway purposes in 1932, as the usual one mill tax has been discontinued this year for the first time.

Kent County now has 201 miles of state trunk lines, 529 miles of improved county roads, and 1,200 miles of township

roads. The state trunk line mileage is now largely improved with hard-surfaced pavements. The 529 miles of road on the county road system consist of 64 miles of hard-surfaced roads and 465 miles of gravel roads of varying widths and thicknesses. The 1,200 miles of township roads cover a multitude of varying conditions. For the most part, however, they are largely unimproved as we understand the term. The last legislature passed a law which, in a period of five years, will turn all of these township roads over to the county road commissions. This act also provides a stipulated amount of money which will be paid to the counties to handle these roads.

CONSTRUCTION

Practically all of our construction work is handled by contract, the supervision of the contracts being taken care of by our engineering department. The construction program for any particular year is decided upon and a budget set up during the previous year. Our engineering department then proceeds to prepare surveys, plans, and specifications for each project. From time to time the various projects are advertised for bids and contracts let for the execution of the work. The specifications used for this work are those which have been adopted by the Michigan State Highway Department, together with such special provisions as appear to be necessary to fit any particular contract. Our engineering department does all of the necessary staking, prepares estimates twice a month, and maintains complete supervision over the work on all contract jobs.

Very little construction work is handled by our own forces. There is an occasional small job which does not seem to lend itself to the contract method, and in these cases the work is handled through our maintenance department. We do not ordinarily have a construction organization, other than our engineering department. The construction work being carried on this winter for the relief of unemployed is an exception to the rule. At the present time we are handling considerable grade-widening work with our own forces, using mostly hand methods in carrying out the work and employing about 500 men at a time. Our construction contracts include widening and reconstructing of existing pavements, placing of new paved roads, constructing of gravel roads, and rebuilding and widening of existing township roads which have been graveled in pretty good shape but have narrow grades.

Our annual construction program usually includes also a few bridges. Practically all of the bridges up to one-hundred-foot span are designed in our own office, and contracts for the work are let and supervised in a manner similar to that of the road construction projects. For bridges greater than 100-foot span we usually operate under a state reward bridge law, which provides for a 50-50 split between the state and county

on the cost, with the engineering work handled by the state highway department. During the past year we have constructed bridges ranging from the low-cost type of about $65.00 per lineal foot to high-type bridges in the same class with the state trunk-line work. The low-cost type of bridge is becoming more and more important as we absorb the lighter traveled roads. One specific example constructed in 1931 gave us a very good bridge at about $65.00 per lineal foot. In this case the bridge was 45 feet long and consisted of a deck of continuous rolled steel beams and reinforced concrete superstructure resting on a treated wood-piling substructure. A concrete guard rail of the rail fence type was used. This bridge provides a 21-foot clear roadway with strength to meet our legal loading requirements, and also presents a very good appearance. This job was also handled by contract.

There are many advantages in handling construction work by contract rather than by direct construction; and it is my belief that over a period of years a great deal of money can be saved by the contract method, provided, of course, that adequate engineering supervision is furnished.

MAINTENANCE

In handling our maintenance work, the county has been divided into six maintenance districts. Our main plant at Grand Rapids is located in one district, and each of the five other districts has a garage which serves as headquarters for all of the men and equipment used in that district. All major repair work is taken care of at the Grand Rapids shop, only minor repair work, greasing, etc., being handled at the district garages.

In each of the districts there is a district foreman or superintendent, who has complete charge of all maintenance work in his territory. The six district foremen are responsible directly to the maintenance superintendent. As we have a large mileage of gravel roads, considerable equipment is used, the most important of which is motor trucks. We operate more than 50 trucks at the present time. As we maintain the 200 miles of state trunk lines in Kent County under a contract with the state highway department, our force and equipment is, of course, considerably larger than in counties where the state trunk-line work is handled by the state organization. It should also be borne in mind that Kent County is about 50% larger in area than the average Michigan county.

In handling the patching of concrete, asphalt, and macadam roads, crews are organized for this particular work and they operate in all districts. All other classes of work, however, are taken care of by the district organization in each district.

GRAVEL

Out of a total of 730 miles of both state and county roads, we maintain a little over 500 miles of gravel surfaces. It is readily seen, therefore, that our big job is that of gravel road maintenance. Time will not permit of a detailed account of our gravel road maintenance methods in this report. Briefly, however, the work consists in keeping the surfaces smooth at all times, adding sufficient gravel to maintain a fairly constant thickness of surface, and in the summer placing a dust layer which will keep the roads clean and pleasant to drive upon. For keeping the surface smooth, we use mainly motor trucks equipped with spring scrapers. These units handle the daily maintenance and are supplemented at long intervals with heavy motor grader equipment.

We have an abundance of local gravel in Kent County and, consequently, gravel surfaces are the logical, low-cost type. We do not consider, however, that gravel as it comes from the natural bank is suitable for this purpose. We operate several screening and crushing plants in gravel pits which belong to the county and also in privately owned pits. Our latest type of gravel plant will handle over 400 cubic yards of finished product per nine-hour day with all material reduced to a maximum size of $\frac{5}{8}$". This plant has two crushers, one to reduce the material to about $1\frac{1}{2}$", and a reduction crusher to make the final reduction to $\frac{5}{8}$". With this kind of material, it is possible to obtain and maintain a very smooth riding surface on these gravel roads, aided, of course, by a dust layer.

CALCIUM CHLORIDE

We do not feel that a gravel road is more than half maintained until the dust nuisance is eliminated. To take care of this situation, we use calcium chloride on all roads having sufficient travel to warrant its use. In 1931, we followed a plan in the application of calcium chloride which seems to be just about ideal. For roads receiving less than 200 vehicles per day, chloride was spread in front of the houses only, covering about 300 feet in front of each house. On roads getting from 200 to 500 vehicles per day, a total of $1\frac{1}{2}$ pounds per square yard was used, applied as needed in three applications of $\frac{1}{2}$ pound per square yard. On roads having 500 to 1,000 vehicles per day, a total of 2 pounds, or four $\frac{1}{2}$-pound treatments, was used. Roads having more than 1,000 vehicles per day received a total of $2\frac{1}{2}$ pounds per square yard, or more, if necessary. We do not believe that roads getting more than 1,000 vehicles per day should be continued as loose-gravel surfaces. These roads should be either paved or provided with some form of bituminous surface. Quite often, however, our finances do not permit us to carry out this kind of program as we would like to and it becomes necessary to

maintain gravel surfaces carrying as much as three or four thousand vehicles per day.

In special cases we have satisfactorily handled as much as 7,000 vehicles per day. We find that on these heavily traveled roads we can keep the surfaces in just about as good condition as on those receiving less than 1,000 vehicles per day. The cost, however, increases with the volume of traffic and where the traffic amounts to four or five thousand vehicles per day the cost may run as high as $2,500 per mile. Obviously, it is not good economy to continue in this manner; but as stated before, it is sometimes necessary until such time as money can be obtained for new construction.

SNOW AND ICE REMOVAL

Not the least of our maintenance problems is the one which requires us to remove snow from 730 miles of road so that they will remain open to traffic at all times during the winter. Our fleet of trucks which handle our gravel maintenance work in the summer come in very handy for this snow removal work in winter. The trucks are equipped with snowplows of various kinds to suit different depths of snow. For a light snow, not over six inches in depth, we find the truck scraper unit very good. For snow from about six inches to two feet in depth, the blade plow of the moldboard type is very efficient. For over two feet in depth, "V" plows mounted on high-powered trucks do the business very well. For extremely heavy drifts it is sometimes necessary to use large "V" plows mounted on tractors. As this type of equipment is so slow we do not use it except when absolutely compelled to. It is more economical to use a greater number of units of the fast-moving equipment. With our present snow removal equipment we are able to cover the entire system of 730 miles in about one-half day, but the 1,200 miles of township roads which we are about to take over are going to present a very difficult problem when it comes to snow removal.

More or less closely associated with snow removal work is that of ice removal and methods of reducing slipperiness on curves, hills, etc. In places where sufficient ice has formed so that we get ruts, we make use of power graders equipped with scarifiers. The scarifiers cut the ice loose and the grader blade pushes it to the edge of the road. There are times when within a few hours our entire road system is covered with a thin sheet of ice. This usually occurs a great many times during the average winter. At such times, whether it be night or day, it is necessary to send out all our trucks equipped with material and men to meet this situation. A combination of calcium chloride and sand is the cure. There are various methods of combining these materials. One very good method is that of mixing them together and placing the mixture in stock piles convenient to the road before the season of ice.

It is then only necessary to load up the material from the stock pile, haul it out onto the road, and spread it over the surface either by hand or by the use of a sand-spreader. Another very good method and probably the one which can be handled with greater speed is that of spreading calcium chloride on the surface with a spreader, and then following with a load of sand spread either directly from the truck or by a sand-spreader hooked behind. This method requires about 300 pounds of calcium chloride and 2½ cubic yards of sand per mile, and these can be applied at the rate of a mile in six minutes. Both of these methods are being used by us at the present time with very good results.

EQUIPMENT MAINTENANCE

Where a large amount of equipment is used in carrying out the activities of a county road department, the matter of equipment maintenance and repairs is of great importance. Our experience in Kent County has shown that a policy of prevention, rather than cure, pays large dividends. We have a well-equipped shop in Grand Rapids with a force of expert mechanics, which enables us to handle practically anything we need in the way of repairs to equipment. In addition to this repair work, however, we have worked out a check-up system which insures every truck being thoroughly overhauled at frequent intervals. A regular schedule has been worked out whereby each truck is taken into the Grand Rapids shop and given a thorough check-up every sixty days. This is, of course, in addition to the regular daily maintenance and repair work which the equipment receives. At the time of the sixty-day check-up, any repair work which is found necessary on the truck is taken care of. This work also includes a thorough cleaning and painting of the truck at least once a year. Sometimes this check-up can be made in a half day or day, but often it is necessary to hold the trucks three or four days in order to take care of everything which is found necessary. At any rate, when the truck goes out after a complete check-up, it is in first-class condition as far as its age will reasonably permit. Equipment other than trucks is handled in much the same manner, but not on a regular schedule. We firmly believe that this so-called prevention work has saved us more money than we have been able to save by expert repair work.

ACCOUNTING METHODS

In order that a county road department may function efficiently, it is extremely necessary that we know what our costs are. It is also well to remember that a cost accounting system is only of value in so far as it furnishes information which leads to greater efficiency and reduced costs on the work. Time will not permit of a detailed discussion of our cost accounting system, but I would recommend to any county a study of the

report on "Uniform Accounting" which was presented at the 1932 American Road Builders' Convention at Detroit. The accounting forms furnished in this report are substantially the forms used in Kent County.

FORESTRY

Many years ago we learned that roadside development work, including the cutting of weeds and brush, should be handled by someone trained in this kind of work. Ordinary maintenance crews cannot distinguish between shrubs and useless brush. As we are in a resort area, it is advisable that our roadsides present the best appearance possible within limited expenditures. We have a trained forester who looks after all of our roadside development work, including trimming, planting, supervision of trimming on utility work, clearing out of obstructed corners at railroad crossings and intersections, and a number of other duties incidental to this work. We have nine county parks, and the work of supervising and caring for all of these parks is also the responsibility of our forester. The cost of this work is not great, but the dividends in the form of good-looking roadsides are large, and our public has indicated its approval of the work which we are doing along this line.

In conclusion, I cannot pass by the opportunity to state some of the general and basic principles which will have a great deal to do with the future of all counties. If counties individually and collectively are going to survive as road-building units in the highway industry, they must religiously follow the famous nine principles which have been laid down by the County Division of the American Road Builders' Association as the basic principles upon which all counties should operate, which are as follows:

1. Favorable legislation
2. Comprehensive plans coordinated with state plans
3. Increased county programs
4. Better business methods
5. Competent supervision
6. Standard construction
7. Regular and systematic maintenance
8. Complete publicity of county operations
9. Active co-operation with other official and unofficial agencies and associations promoting better roads.